POTENTIAL FOR RENEWABLE ENERGY UTILIZATION IN LAKSHADWEEP ISLANDS

Final Report of a study conducted by
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in collaboration with
Department of Non-Conventional Energy Sources

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1. PREAMBLE

The present report is a sequel to the report "Potential for Renewable Energy Utilization in Andaman & Nicobar and Lakshadweep Islands" prepared by the Tata Energy Research Institute and sponsored by the Department of Non-Conventional Energy Sources. The earlier study was based on a field visit to A & N Islands and data available for Lakshadweep Islands. Upon discussions with Lakshadweep Administration, it was felt that a more detailed and separate study was warranted for Lakshadweep Islands. Accordingly a TERI-DNES team visited the islands in the first week of February, 1988, collected relevant information and held discussions with various officials of the administration. The team has taken a fresh look at the situation obtaining in the islands regarding the potential for renewable energy utilization and analyzed the present energy scenario. The following chapters deal with current energy scenario, and outline of the scope for renewable energy utilization and major recommendations, both short term and long term, towards achieving maximum utilization of renewable sources of energy in Lakshadweep Islands.

2. PRESENT ENERGY SCENARIO

2.1 Electricity

All electricity produced in the islands is by means of diesel generators. Table 1.1 gives the island wise installed capacity. The island wise generation of electricity is shown in Table 1.2. The sector wise consumption of electricity and the diesel consumption figures for electric generation are shown in Tables 1.3 and 1.4 respectively. The specific fuel consumption (SFC) varies from 0.26 lit/kWh to 0.35 lit/kWh depending on the size and make of the gen-set, with an average of 0.33 lit/kWh. The per capita electricity consumption has been estimated taking the actual consumption figures since 1977 and estimated population figures. The population of the islands has been increasing steadily since 1931. The percentage decade variation for 1971-81 was +26.53% corresponding to and yearly compound growth rate of 2.38%. However, the NSS data for 1985-86 give a figure of 41,996, corresponding to a compound growth rate of 0.85% from 1981. Using these different growth rates of 2.38% for the period 1977-1981 and 0.85% for the period 1981-1985, the population for each year has been estimated, as shown in Table 1.5, along with the electricity consumption It can be seen that the per capita consumption is increasing rapidly. The trend shows that the demand for electricity will continue to increase, as the islands are becoming more prosperous.

The costs of generation and distribution of electricity are worked out in Table 1.6. Due to the high cost of diesel (about Rs. 4.34 per litre including transport and storage cots), the cost of generation is fairly high at Rs. 2.87 per kWh. If costs incurred in

Table 1.1 : Statement showing installed capacity

Name of Power House	Installed capacity in kW	Total capacity in kW	Derated capacity in kW	Firm capacity in kW	Year of commissioning	Anticipated capacity as on 31-3-88
Minicoy	3 x 250	750	750	750	1987	4 x 250 - 1000
Kavaratti	4 x 250	1000	1000	1000	1987	4 x 250 - 1000
Amini	1 x 24		18		15-8-65	6 x 125
	1 x 50		45		14-3-77	
	3 x 65	269	2 x 60	183	5-4-83	
					11-4-83	750
					4-4-84	
Kalpeni	2 x 25.6		2 x 18		1979	5 x 65
	1 x 50		1 x 45		2 in 1983	5 x 65
	3 x 65	269	3 x 60	261	1 in 1987	325
Andrott	3 x 250	750	750	750	1987	3 x 250 - 750
Agatti	2 x 50		2 x 45		1973	1 x 88
	2 x 65		2 x 60		1974	3 x 80
	1 x 88	318	1 x 70	280	1983	1 x 250
					1987	
Kadmat	1 x 5.6		1 x 6		1970	
	1 x 8.4		1 x 18		1971	
	1 x 24		3 x 45	159	1982	
	3 x 50	188			1976	8 x 50 400
					1983	
					1984	
Kiltan	1 x 5.6				1971	
	2 x 27.2		2 x 18		1972	
	3 x 48	204	3 x 35	141	1983	8 x 65 260
					1976	
Chetlat	2 x 27		2 x 18		1973	1 x 65
	1 x 15		1 x 12		1982	1 x 50 115
	1 x 35		1 x 25		1962	
	1 x 56	160	1 x 45	118		
Bitra	1 x 5.6		----		1984	3 x 24 - 72
	1 x 8.4		1 x 6		1982	
	1 x 9.6		1 x 7		1982	
	1 x 24	48	1 x 8	31	1985	
Bangaram	1 x 8.4		1 x 6		1985	3 x 24 - 72
	1 x 16		1 x 12		1987	
	2 x 24	72	2 x 24	66		
Total		4055 kW		3739 kW		5314 kW

Table 1.2 : Island wise generation of electricity.
(January 1987 - December 1987)

Name of Power House	Units Generated	Units used in Power House	Units sent out
Minicoy	12,66,276	10,129(0.8%)	12,56,147
Kavaratti	14,21,560	33,128(2.3)	13,88,432
Amini	4,19,962	9,284(2.2)	43,06.78
Andrott	8,72,941	7,099(0.8)	8,65,842
Kalpeni	3,95,852	10,732(2.7)	3,85,120
Agatti	3,91,204	5,213(1.3)	3,85,991
Kadmat	2,56,503	11,035(4.3)	2.45,468
Kiltan	2,28,187	5,901(2.6)	2,22,286
Chetlat	1,79,871	7,949(4.4)	1,71,922
Bitra	23,397	2,371(10.1)	21,026
	54,55,753	1,02,841(1.9)	53,52,912

Table 1.3 : Sector wise consumption of electricity (January 1986 - December 1986)

	Commercial	Street Light	Domestic
Minicoy	69184	40476	669928
Kavaratti	608870	53126	549659
Amini	71506	58084	217409
Andrott	138229	122054	419816
Kalpeni	63930	60981	226886
Agatti	17802	30524	247492
Kadmat	45127	25451	145311
Kiltan	52698	16354	124324
Chetlat	26193	14116	100191
Bitra	2567	3413	10990

Table 1.4 : Diesel consumption, island wise

(April 1986 - March 1987)

	Litres
Minicoy	520153
Kavaratti	568563
Amini	159795
Andrott	314911
Kalpeni	149574
Agatti	162487
Kadmat	125845
Kiltan	104643
Chetlat	88179
Bitra	14001
	2208151

Table 1.5 : Per capita consumption of electricity

Year	Population (estimated)	Electricity Consumption (kWh)	Per Capita Consumption (kWh/person/yr)
1977-78	37,507	600,198	16.0
1978-79	38,399	689,105	17.9
1979-80	39,313	928,000	23.6
1980-81	40,249$^+$	1,070,000	26.6
1981-82	40,592	1.440,000	35.5
1982-83	40,939	1.785,000	43.6
1983-84	41.288	2,414,000	58.5
1984-85	41,641	3,193,000	76.7
1985-86	41,996	4,013,000	95.5

$^+$Figure for 1981 census.

Sources: Basic statistics, 1985, NSS data, 1985-86.

Table 1.6 : Statement of expenses for electricity generation (1985-86)

A.	Cost of Generaton	
1.	Cost of fuel (HSD)	Rs 88,65,259
2.	Lubricants and other consumables	Rs 15,46,841
3.	Salaries of staff	Rs 14,75,055
4.	Wages of labour	Rs 66,081
5.	Repair and maintenance of building plant and equipment	Rs 3,21,551
6.	Freight, shipping and other conveyance charges	Rs 2,50,729
7.	Depreciation on operating plants	Rs 7,01,115
8.	interest on capital	Rs 14,02,230
	Total Annual Charges for Generation	Rs 146,28,861
B.	Technical Details	
1.	Installed capacity, kW	2766
2.	Generation, kWh	50,94,000
3.	Auxiliary consumption, kWh	89,000
4.	T&D losses, kWh	9,92,000
5.	Electricity sold, kWh	40,13,000
6.	Oil consumed, kL	1914
7.	SFC (lit/kWh)	0.376
C.	Cost of Generation, Rs/kWh	2.87
D.	Cost of Distribution	
1.	Salaries of staff	Rs 15,89,652
2.	Wages of labour	Rs 1,82,309
3.	Repairs of lines, poles transformers etc.	Rs 30,182
4.	Depreciation of assets	Rs 5,01,808
5.	Salaries of billing and collection staff	Rs 6,30,751
6.	Depreciation on general equipment including office furniture	Rs 1,27850
7.	Interest on capital	Rs 12,59,316
	Total Annual Cost of Distribution	Rs 43,21,868
E.	Total annual cost of generation and distribution	Rs 189,50,729
F.	Cost of electricity sold (Rs/kWh)	4.72

Source: AEE (Electrical), U.T. of Lakshadweep.

distribution are also considered, the price of electricity sold works out to be Rs. 4.72 per kWh. It is in this economic context that renewable sources of energy have to be evaluated for electricity generation. The economics of power generation through renewables is examined in detail in the next chapter. Apart from economics, there seem to be some ecological factors to discourage the use of diesel on the islands. During monsoon months it is not possible to transport diesel to the islands and all the diesel requirements in monsoon are met by storing sufficient quantity before the onset of monsoon. The storage facilities are not very good and diesel is usually stored in barrels. There seem to be some leakage from these barrels (about 1% per year), and hence there is the danger of diesel percolating through the soil which is highly permeable (permeability about 0.02 cm/sec). The month wise and island wise quantity of diesel oil stored is shown in Table 1 7. It is difficult to work out possible diesel leakages into ground based on the information available, but Table 1.7 shows that there is a clear possibility of the ground water getting contaminated with diesel. In fact, officials of the power house at Kavaratti have informed that the people living near the power house were complaining of diesel contamination in their wells. Because of these reasons, it is desirable to minimize the use of diesel on the islands to the extent possible.

Table 1.7 : Stock of HSD oil from January 87 to December 87

Month	Minicoy		Kavaratti		Amini		Andrott		Kalpeni		Agatti		Kadmat		Kiltan		Chetlat		Bitra	
	Tank (KL)	Barrel (Nos.)	Tank (KL)	Barrel (Nos.)	Tank (KL)	Barrel (Nos.)	Tank (KL)	Barrel (Nos.)	Tank (KL)	Barrel (Nos.)	Tank (KL)	Barrel (Nos.)	Tank (KL)	Barrel (Nos.)	Tank (KL)	Barrel (Nos.)	Tank (KL)	Barrel (Nos.)	Tank (KL)	Barrel (Nos.)
Jan.87	99	-	120	400	42	-	90	250	60	114	60	90	45	95	33	-	45	65	15	31
Feb.87	50	-	120	150	28	-	90	530	60	58	60	30	45	45	44	-	45	25	15	25
Mar.87	92	-	120	878	74	-	90	390	60	190	54	-	45	245	45	185	43	-	15	20
Apr.87	105	435	120	625	75	225	90	640	60	290	42	-	45	200	45	145	45	250	15	15
May 87	105	890	120	965	75	145	90	510	60	220	60	185	45	140	45	105	45	215	15	11
Jun.87	105	630	120	725	75	70	90	370	60	165	60	125	45	85	45	60	45	185	15	6
Jul.87	105	365	120	460	75	-	90	245	60	100	60	65	45	25	45	15	45	150	15	-
Aug.87	105	105	120	195	58	-	90	120	60	40	60	-	37	-	39	-	45	110	13	-
Sep.87	78	-	108	-	42	-	90	-	56	-	48	-	24	-	30	-	45	65	12	-
Oct.87	32	-	60	-	27	-	44	-	55	-	34	-	12	-	20	-	45	25	11	-
Nov.87	24	-	120	50	49	-	13	-	60	185	20	-	34	-	29	-	44	-	10	-
Dec.87	88	-	114	-	33	-	90	605	60	115	60	75	21	-	19	-	39	-	9	-

200 lit/barrel
losses during transport : 7%
losses during storage = 1% per year

2.2 Domestic Energy Consumption

The domestic energy consumption is mainly for cooking. No energy surveys have been done so far and hence the cooking energy requirements have to be estimated from whatever sources available. All the solid fuel used on the islands is derived from coconut trees. Kerosene is also used in the islands for cooking and lighting and the island wise consumption is shown in Table 2.1. the common fuel for cooking consists of petiole (midrib of coconut leaf), spathe, shell and husk. Kerosene use for lighting seems to be fairly small, as can be seen from Table 2.2 as almost 95% of the residences in Lakshadweep are electrified. Hence it may be assumed that all the kerosene consumption is for cooking only. To estimate the biomass (coconut waste) consumption for cooking, the following procedure is used.

i) The per capita consumption of food (rice and other cereals and fish) has been obtained from the NSS data shown in Table 2.3. This data shows that the average rice consumption is 0.304 kg/day/person and that the fish consumption is 0.095 kg/day/person. A quick survey of 5 households in Kavaratti gave average figures of 0 37 kg rice/day/person and 0.12 kg fish/day/person, which are quite close to the figures from NSS data.

ii) The population figures for the year 1986-87 for each island were estimated from 1985-86 NSS data.

iii) A cooking experiment was performed in Kavaratti,

Table 2.1 : Kerosene consumption in the islands (1986-87), litres

Minicoy	68,338
Kavaratti	51,947
Amini	21,702
Andrott	41,851
Kalpeni	22,872
Agatti	13,863
Kadmat	10,335
Kiltan	10,635
Chetlat	19,462
Bitra	7,200
	268,205

Table 2.2 : Percentage distribution of households by source of energy used for lighting

Name of Island	Source of energy used for lighting Electricity	Kerosene	Others	All
(1)	(2)	(3)	(4)	(5)
Agatti	97.49	2.09	0.42	100.00
Amini	97.51	1.70	0.79	100.00
Andrott	90.81	7.97	1.22	100.00
Bitra	94.23	5.77	-	100.00
Chetlat	86.52	4.85	8.63	100.00
Kadmat	98.02	1.32	0.66	100.00
Kalpeni	95.81	3.35	0.84	100.00
Kavaratti	92.96	1.85	5.19	100.00
Kiltan	95.00	4.78	0.22	100.00
Minicoy	98.96	0.94	0.10	100.00
All Islands	94.87	3.22	1.91	100.00
All-India[1]				
Rural (1973-74)	6.55	91.67	1.78	100.00
Urban	53.48	45.99	0.53	100.00

1. Ref: Sarvekshna, Vol.I, No.2, October 1977.

Source: Report on house-to-house socio-economics survey of Lakshadweep, National Sample Survey Organisation, 1986.

Table 2.3 : Quantity of consumption (in 0.00 kg.) of some selected items of consumption (per person for a period of 30 days.)

Name of Island	Item of Consumption			
	Rice & Rice Products	Total Cereals	Tuna Fish	Sugar
(1)	(2)	(3)	(4)	(5)
Agatti	9.78	10.69	5.97	2.20
Amini	9.94	11.16	2.36	1.79
Andrott	9.78	10.51	1.71	1.85
Bitra	10.70	12.98	3.99	2.77
Chetlat	10.42	12.41	2.26	2.12
Kadmat	9.32	10.23	1.01	1.84
Kalpeni	9.66	10.85	1.82	1.94
Kavaratti	9.01	10.10	3.27	1.94
Kiltan	9.37	10.44	1.16	1.57
Minicoy	6.71	8.72	4.20	2.06
All Islands	9.13	10 35	2.86	1.93

Keywords

RENEWABLE ENERGY CONSUMPTION

LAKSHADWEEP

burning coconut waste in the traditional chullah, to estimate the fuel consumption. This gave a value of 2.56 kg fuel per kg of raw rice. As most of the cooking is done by boiling (roti is seldom used in the islands), it is assumed that this figures is valid for all cooking items.

iv) From the above figures, a fuel consumption value of 1.13 kg/person/day is obtained. Multiplying this by the population of each island, the total biomass consumption per year, assuming that all cooking is done with biomass, is obtained for each island.

v) The kerosene consumption figures for each island for 1986-87 are available. Assuming that each litre of kerosene can replace 11.5 kg of biomass, the biomass replaced by kerosene is estimated for each island.

vi) The biomass values obtained in step (v) are subtracted from the biomass values obtained in step (iv), and the resulting net biomass consumption figures are tabulated for each island.

The values obtained as above are shown in Table 2.4.

2.3 Industry

Industrial activity in the sense in which it is used in the mainland is almost absent in the islands. However, the following items are exported to the mainland - i) copra ii) coir and iii) fish both in cans and in a form called 'mas'. Copra making does not

Table 2.4 : Estimation of biomass consumption for cooking

Island	Population 1985-86	Population[+] 1986-87	Biomass Consumptionfor cooking (tons/yr)[‡]	Kerosene Consumption 1986-87 litres	Biomass equivalent (tons/yr)	Net Biomass Consumption (tons/yr)
Minicoy	6900	6958	2870	68,338	786	2084
Kalpeni	3512	3542	1461	22,872	263	1198
Andrott	7376	7439	3068	41,851	481	2587
Agatti	4487	4525	1866	13,863	159	1707
Kavaratti	6505	6560	2706	51,947	597	2109
Amini	5559	5606	2312	21,702	250	2062
Kadmat	3299	3327	1372	10,335	119	1253
Kiltan	2520	2541	1048	10,635	122	926
Chetlat	1660	1674	690	19,462	224	466
Bitra	178	180	74	7,200	83	--
		42352	17467	268205	3084	14392

[+] estimated

[‡] Assuming all cooking energy is obtained from biomass

make use of any external energy. The coir industry uses only electricity. The canning factory uses both electrical and thermal energy, the thermal energy requirements being met by furnace oil. The 'mas' making, however, uses significant quantities of thermal energy which is currently met exclusively by the coconut waste (biomass) available on the islands. These are dealt separately in the following.

Coir Industry

Coir is made from coconut husk (the outer part after the shell is removed) in a series of steps involving crushing, soaking, bursting, defibring and shifting. The electricity consumption for the coir factory in Kavaratti was 16550 kWh/yr, and the annual production of coir was 24 tons. Hence the specific electricity consumption can be estimated as about 0.7 kWh/kg.

Canning Factory

The canning factory at Minicoy uses both thermal energy and electrical energy. The average consumption of furnace oil is 150 litres per 1000 cans. Furnace oil is purchased at 2.00 Rs/litre. Though the production was high at 1,96,000 cans/year in 1975 and 1,76,000 can/yr in 1976, it has dropped to 1,04,000 cans/year in 1987, owing to shortage of furnace oil and empty cans. The electricity consumption is estimated to be 0.45 kWh/can.

Table 2.5 : Fish used for mas making

Island	[illegible]		1984		1985		1986		Average		Biomass Consumed for mas making (tons/yr)
	(1) Fish used for mas (kg)	(2) Mas produced (kg)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	
Minicoy	90,800	18,385	1,85,000	37,000	1,25,000	25,000	6,97,000	1,35,600	2,74,450	53,997	192
Kalpeni	23,638	4,243	15,000	2,535	37,760	6,040	13,600	2,100	22,500	3,730	16
Andrott	--	--	--	--	--	--	--	--	--	--	--
Agatti	1,03,360	20,676	19,52,000	3,99,410	15,85,749	3,17,131	14,38,800	2,69,130	12,69,978	2,51,587	889
Kavaratti	1,99,167	39,195	13,405	2235	--	--	1,53,000	29,667	91,393	17,774	64
Amini	25,148	4,275	35,130	7,784	--	--	--	--	15,070	3,015	11
Kadmat	35,600	6,000	--	--	--	--	--	--	6900	1500	6
Kiltan	57,700	11,050	1,01,000	20,200	1,33,000	26,650	49,260	12,050	85,240	17,488	60
Chetlat	88,000	19,500	2,500	500	3,22,000	64,200	1.02,930	22,532	1,28,858	26,683	90
Bitra	1,59,359	31,631	1,15,890	20,877	1,28,333	24,710	4,01,317	74,786	2,01,225	38,000	141
Suheli	3,00,000	60,000	7,25,765	1,30,404	96,394	16,335	2.40,255	42,629	3,40,603	62,342	238
Total	10,82,772	214,955	31,45,690	620,945	2428,236	480,066	3096,162	538.494	2438,217	476,115	1707
Fish landed	43,01,000		53,31,000		46,29,000						

'Mas Making'

As the fish caught in the islands can decompose fairly rapidly, it is converted into a dried product called 'mas' and exported to the mainland. The preparation of mas involves chopping of head, removing viscera, heating to about 80-90°C in saline water, smoking and then sun-drying. the dried fish can be stored upto 1-1/2 years. Mas making is an energy intensive activity and the only source is coconut waste. Mas is prepared mostly in open air on inefficient chullahs. The fuel requirements for mas making are not known. A very brief survey at Minicoy indicated that about 0.7 kg biomass is used for each kg of fish (raw). The island wise biomass consumption for mas making can be estimated, provided the island-wise mas production figures are available. These are highly variable, as the fish catch is variable at each island for different years The island-wise figures of fish used for mas making as well as those of the mas prepared are shown in Table 2.5. The values shown in Table 2.5 were obtained from the fisheries department. There seems to be some accounting problems with the data. For example the fish catch for the islands was 4629 tons in 1985. The fish used for mas making was 2428 tons. The internal consumption of fish can be calculated as about 1460 tons, which gives a total of 3888 tons, leaving about 741 tons unaccounted. The reason for this discrepancy is not known.

2.4 Miscellaneous

Energy is consumed in several other activities, chiefly in transportation. Jeeps are in use in some islands and a bus is being run for public transport in Kavaratti. There is heavy oil consumption in inter-islands transport by sea, as well as transport to mainland, but this data has not been collected as it would not be relevant to the present study.

3. POTENTIAL FOR RENEWABLE ENERGY UTILIZATION

3.1 Biomass Energy

Biomass is a form of renewable energy and can be used for a variety of applications including power generation. There does not seem to be any scope for utilizing animal dung in biogas digesters chiefly because i) the cattle population is low ii) the size of the cattle is small iii) water table is high, and iv) construction material is not available in the islands. A fixed dome biogas plant constructed in Kavaratti in a cattle shed had been non-functional. However, there seems to be ample scope for utilizing coconut waste As coconut waste is the only fuel used for cooking and 'mas' making, the availability of excess biomass has to be carefully worked out. Unfortunately, a rigorous exercise is not possible owing to lack of data on existing level of utilization, yield of coconut waste etc.

The island-wise consumption of biomass for

cooking and 'mas' making has been worked out in the last chapter. . Some rough figures had been made available from the agriculture department regarding the yield of biomass. These are listed below.

Density of plants	:	260 trees/ha
Nut yield		58 Nuts/tree/year
Leaf yield		12 leaves/year/tree
Average wt. of leaf	:	10-12 kgs
wt. of dry husk per nut	:	300-370 gms
wt. of shell per unit		80 gms

If we assume a 30% moisture in the fresh leaf and a 10% moisture in dried leaf, the weight of dried leaf can be calculated as about 7.8 kg. With the help of the above figures, the total biomass yield (including leaves) is calculated as 1.87 kg/nut. The island-wise nut production is available and from this the biomass availability can be calculated. The working of excess biomass calculation is shown in Table 3.1. The numbers have to be taken cautiously, but it seems there is some excess biomass in Kalpeni, Andrott, Kavaratti, Amini and Kadmat. Almost no biomass is available in Bitra. In fact, during the visit to Bitra, the team has been informed that there is an acute shortage of fuel in Bitra and that sometimes it is brought from other islands. A similar situation exists in Minicoy also.

In the five islands, where excess biomass seems to be available, power generation from biomass through gasification is feasible. The biomass available, mostly

Table 3.1 : Calculation of Excess Biomass for each island

Island	Production of nuts in 1986-87 (lakhs)	Total Biomass production[†] (tons/yr)	Fish used for mas (tons/yr)	Biomass used for mas (tons/yr)	Biomass used for cooking (tons/yr)	Excess biomas available (tons/yr)	Total capacity of power plant (kW)	Electicity generated (million
Minicoy	19.0	3553	274.5	192	2084	1277	--	--
Kalpeni	34.8	6507	22.5	16	1198	5293	594	2.6
Andrott	48.84	9133	--	--	2587	6546	753	3.3
Agatti	27.3	5105	1270	889	1707	2509	--	--
Kavaratti	36.38	6803	91.4	64	2109	4630	525	2.3
Amini	31.5	5890	15.1	11	2062	3817	434	1.9
Kadmat	24.8	4638	8.9	6	1253	3379	388	1.7
Kiltan	11.0	2057	85.2	60	926	1071	--	--
Chetlat	6.0	1122	128.9	90	466	566	--	
Bitra	0.8	150	201.2	141	--	9	--	--
Suneli	5.71	1068	340.6	238	--	830	--	--
Total	246.0	46026	2438.3	1707	14,392	29,927	2694	11.8

[†] assuming a total biomass yield of 1.87 kg per nut

in the form of husk, is not suitable for gasification directly, but can be used after pulverisation and pelleting, the technology for which is available at M/s. Alfred Herbert (India) Ltd, Bangalore. Gasification of pelletised biomass (husk) has not so far been tried in the country, but is strongly feasible. Husk is currently available at a price of Rs. 28 per 1000 husks (about Rs. 84 per tonne) for use in coir factories. Besides, coir pith, which is a waste by-product of coir factories, is also available, though not in significant quantities, at no cost. The capacities of power plants based on coconut waste and the annual generation (net) expected from such power plants are shown in Table 3.1. the availability of coir pith from coir plants and the expected electricity generation (net) are shown in Table 3.2. The economics of power generation from coconut husk are worked out in Table 3.3. It can be seen that the cost of generation is lesser than the present generation cost from diesel sets.

3.2 Potential for Wind Energy Utilization

Wind electricity generation has been shown to be economically quite viable for certain regions in India (Technoeconomics of Electric Power Generation Through Renewable Sources of Energy - A Comparative Study, by V.V.N. Kishore and K. Thukral). The cost of generation varied from Rs. 1.5 to Rs. 4.0 per kWh, depending on the site. The available wind speed data for some of the

Table 3.2 : Coconut pith production at fibre extraction centres in 1984-85

Island	Quantity of pith (tons/yr)	Expected Annual generation (net) of electricity (kWh)
Kavaratti	24	12,000
Andrott	61	30,500
Amini	18	9,000
Kadmat	17	8,500
Total	120	60,000

Source: Report on waste utilization of Lakshadweep Islands by NEERI.

Table 3.3 : Cost of Electricity from Power Plants based on Briquetted waste through gasification

Basis	:	1 kW
Derated capacity	:	0.75 kW
Annual generation (@ 4380 hrs/year)	:	3285 kWh (gross)
Fuel requirement (@ 1.2 kg/kWh)	:	4599 kg/year
Diesel requirements (@ 0.12 lit/kWh)	:	394.2 lit/year
Capacity of briquetting machine	:	1.4 kg/hr
Electricity consumption for briquetting (@ 0.1 kWh/kg)	:	459.9 kWh
Auxiliary consumption of power plant (10% of gross generation)	:	328.5 kWh
Net generation	:	2496.6 kWh
Capital cost of power plant	:	Rs. 7,000
Capital cost of briquetting machine	:	Rs. 9,065
Total capital cost	:	Rs. 16,065
Capital recovery factor (@ 15 yr life and 12% discount rate)	:	0.1468

Annual costs:

Recovery on capital	:	Rs. 2358
OMR costs (@ 10% of capital)	:	Rs. 1606
Diesel costs (@ Rs. 4.0/litre)	:	Rs. 1577
Lube oil costs	:	Rs. 173
Cost of Biomass	:	Rs. 460
		Rs. 6174
Cost of Electricity	:	2 5 Rs/kWh

islands in Lakshadweep, shown in Table 3.4, indicate that good wind speeds prevail in the monsoon for Kavaratti, Agatti and Amini.

A 20 kW wind electric generator is in operation in Kavaratti since October 1987. The performance of this WEG is shown in Table 3.5. As the WEG has been operating only for a short while, it is difficult to evaluate the cost of generation. However, daily average wind speeds are available for Kavaratti (Scheme Report for 20 kW pilot project on wind generation for U.T. of Lakshadweep). Also, data from a wind classifier installed near the WEG is available for 8 months. The available data can be extrapolated to the hub height (14 m.) and with the help of the power curve for the machine, monthly and annual generation can be estimated. The power curve is shown in Fig. 3.1. The monthly generation obtained, both from daily mean speeds and from wind classifier data, are shown in Table 3.6. It can be seen from this table that there is no matching between estimates from different data. The actual generation also does not correlate with estimations. This clearly shows the problems involved in estimating wind energy potential without adequate data base. The cost of generation, taking the expected annual generation, is worked out in Table 3.7. The cost is higher than that of diesel electricity. The reasons for higher costs appear to be **(i)** higher initial cost @ 36.800 Rs/kW (compared to 15,230 Rs/kW for the wind

Table 3.4 : Monthly average wind speeds at 14 m. height for some islands (m/s)

Month	Kavaratti	Minicoy	Agatti	Amini	Andrott
Jan	1.00	2.57	1.39	2.32	1.5
Feb	0.96	2.61	1.28	2.97	1.5
Mar	2.21	2.79	2.15	3.18	1.47
Apr	2.49	2.98	2.39	3.50	1.47
May	4.41	4.87	4.40	4.87	1.83
Jun	8.77	5.85	7.17	7.87	1.86
Jul	8.95	6.1	8.0	8.87	2 11
Aug	8.61	5.6	7.57	8.10	2.58
Sep	5 43	5.0	5.14	6.59	2.05
Oct	2.43	3.79	3.09	5.72	1.03
Nov	3.11	2.9	1.79	2.15	0.93
Dec	1.44	2.27	1.69	1.99	0.90

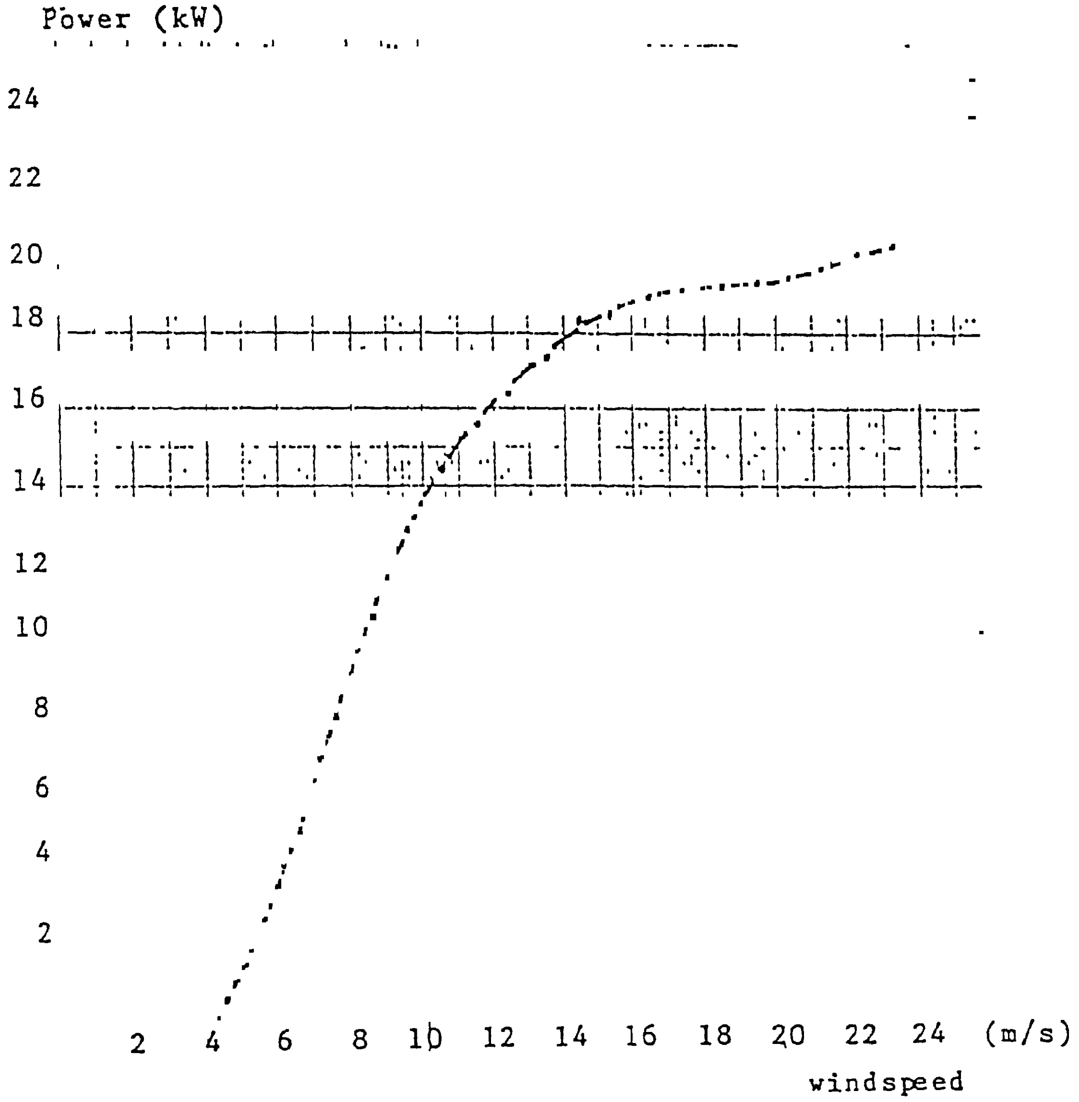
Note: The above data, except for Kavaratti, has been compiled from "Wind Energy Data for India" by A Mani and D.A. Mooley.

Table 3.5 : Performance record of 20 kW wind energy converter at Kavaratti

Date	Daily generation in kWh	Monthly generation kWh
18-10-87	1	
19-10-87	35	
20-10-87	12	48
3-11-87	2	
4-11-87	5	
10-11-87	1	
11-11-87	3	
13-11-87	29	
14-11-87	3	
15-11-87	3	
25-11-87	1	
29-11-87	3	50
2-12-87	7	
3-12-87	3	
4-12-87	34	
5-12-87	26	
6-12-87	41	
10-12-87	3	
30-12-87	4	108
1-1-88	1	
6-1-88	29	
7-1-88	17	
10-1-88	3	
13-1-88	9	
15-1-88	2	
16-1-88	6	
17-1-88	12	
18-1-88	2	
19-1-88	1	
21-1-88	9	
22-1-88	34	
23-1-88	10	
25-1-88	2	
27-1-88	1	138
		344 kWh

Source: Mr. C.M. Ahamed, AEE (Electrical) U.T. of Lakshadweep

Model 18 Sp



18.5 kW Oddermølle i Ranum

Foreløbig effektkurve pr. 26/2-1986

Fig 3.1 : Power Curve for the 20 kW Wind Electric Generator at Kavaratti.

Table 3.6 : Monthly generation of electricity from the 20 kW WEG at Kavaratti

Month	Av. wind speed at hub height (m/s)	Generation, taking daily average wind velocities, kWh/month	Generation, taking wind classifier data kWh/month	Actual generation, kWh
Jan	1.00	60	308	138
Feb	0.96	144	---	---
Mar	2 21	250	---	---
Apr	2.49	84	---	---
May	4.41	2206	---	---
Jun	8.77	8364	1713	---
Jul	8.95	8126	1417	---
Aug	8.61	7913	369	---
Sep	5.43	2285	93	---
Oct	2.43	437	108	48
Nov	3.11	1457	95	50
Dec	1.44	0	1193	108
Total		31324		

machines at Okha, for example) and (ii) lower hub height of 14 m where wind speeds may not be as high as desirable due to interference from coconut plantations. It should be mentioned that the wind speed data, on which the feasibility report was based, was collected by the Lakshadweep Harbour works at a site which is different from the actual site of the WEG. The data from the wind classifier should have given a better understanding of the site, but this has not been the case, the reasons for which can be (i) lower height of installation (10 m.), interfering with coconut plantation and (ii) larger wind speed interval (2 m/s).

There had been many operational problems related to the maintenance of the WEG. Especially, disturbance in the grid had been causing frequent break downs. For any future evaluation of the potential of wind energy for the islands, the grid characteristics should be carefully analysised. The grid characteristics for different islands are shown in Table 3.8.

It is too early to come to firm conclusions regarding the potential of wind electric generation in the islands. The economics can be significantly improved by procuring WEGs at competitive prices and by installing them at suitable location and at proper heights. Considering the growing availability of machines from several manufactures, this is a distinct possibility. Apart from economics, there are environmental advantages of resorting to wind

Table 3.7 : Costs of Wind Electricity generation

Rated capacity	:	20 kW
Station	:	Kavaratti
System cost	:	Rs. 5,84,000
Erection and Commissioning	:	Rs. 1,17,355
Commision for Indian agents	:	Rs. 34,727
Total capital cost	:	Rs. 7,36,082
Annual costs		
Recovery on capital (@ CRF of 0.1468)	:	Rs. 1,08,057
OMR costs (@ 3% of capital)	:	Rs. 22,082
Total annual costs	:	Rs. 1,30,140
Annual generation (expected)	.	Rs. 31324 kWh
Generation cost	:	4.15 Rs/kWh

electricity. As can be seen from Table 3.4, wind speeds are highest in monsoon, during which time diesel is stored in large quantities in all the islands, leading to a possible ground water contamination as mentioned earlier. The use of wind electricity can reduce the storage requirements of diesel oil, and hence is highly desirable.

3.3. Potential for Solar Energy Utilization

As about 80% of the total land area available in the islands is covered with coconut plantations the ultimate potential for solar energy utilization appears to be limited However, certain end-use specific applications using solar energy might be examined. These include solar desalination for providing drinking water, solar photovoltaic systems for power generation, street lighting etc. and ocean thermal energy conversion (OTEC).

3.3.1 Solar Stills

In the islands Bitra and Suheli the ground water is saline (salinity>15,000 ppm.) However, there is considerable economic activity on these islands, and Suheli is presently un-inhabited. Use of solar stills to provide drinking water would be quite appropriate as it does not involve conventional energy, there are no mechanical moving parts and maintenance is relatively easy. A solar desalination plant with a total collector area of 750 m^2 and with a rated output of 2000 lit/day

Table 3.8 : Grid characteristics for different islands

						Tolerance	
	H.T.		L.T.			Voltage	Frequency
Minicoy	3.3 KV 52A	50 Htz	400/230V	200A	50 Htz	± 1%	± 1%
Kavaratti	3.3 KV 42A	50 Htz	400/230V	260A	50 Htz	-do-	-do-
Amini	-		400/230V	300A	50 Htz	-do-	-do-
Andrott	3.3 KV 39A	50 Htz	400/230V	230A	50 Htz	-do-	-do-
Kalpeni	-		400/230V	243A	50 Htz	-do-	-do-
Agatti	-		400/230V	274A	50 Htz	-do-	-do-
Kadmat	-		400/230V	199A	50 Htz	-do-	-do-
Kiltan	-		400/230V	134A	50 Htz	-do-	-do-
Chetlat	-		400/230V	127A	50 Htz	-do-	-do-
Bitra	-		400/230V	20A	50 Htz	-do-	-do-

Source: C.M. Ahamed, AEE (Electrical)

is currently under use in Bitra. A visit to Bitra and an examination of the plant brought the following points to notice.

1. Actual output of the plant is 800 lit/day as against the rated output of 2000 lit/day.
2. There is considerable algae growth both in the basins and on the inside of glazing.

The reduction in output might be due to the algae growth. This can be controlled by using bleaching powder. Taking the investment roughly as Rs 2000/m^2 and the current output of 800 lit/day, the cost of production of drinking water comes to about 80 paise/litre. It might be desirable to examine alternate methods of production like reverse osmosis, multistage flash distillation (MSF) using coconut waste for steam generation etc. Both these methods need electricity for driving motors, pumps etc. However, reverse osmosis may not be applicable for high salinity water and sea water. For obtaining costs of MSF systems etc., the desalination department of BARC, Bombay may be contacted.

3.3.2 Solar Photovoltaic Systems

Solar photovoltaic (SPV) systems are being used for street lighting, and for powering TV transmitter stations in the islands. A 5 kW_p SPV power station is being installed at Bitra at a total cost of Rs. 10 lakhs. The economics of electricity generation from SPV systems is worked out in Table 3.9. It can be seen that the cost of electricity is as high as Rs. 27/kWh. The economics of SPV street lighting systems would be similar. A further problem with SPV street lights is that the lights are designed to operated for about 6 hrs. in the night. As conventional street lights operate throughout the night, some dissatisfaction might be expected from people in places where SPV systems are installed.

3.3.3 OTEC

This technology makes use of the difference in temperature between the surface and deeper layers of the ocean. The difference is about 22°C, and can sustain the operation of a low temperature organic Rankine engine with one of the freons or ammonia as working fluid. Some major problems which are not solved effectively as yet are high parasitic consumption (40%), biofouling etc. A further problem for Lakshadweep islands would be the non availability of adequate land area The cost of power generation works out to be Rs 8.06/kWh, as shown in Table 3.10. The generation cost is considerably higher than the figure of Rs. 3.70/kWh quoted by MECON. To clarify the issue a meeting was arranged on 23.5.88 in which representatives of TERI, DNES, and MECON were present. The representative of MECON informed that interest on capital was not included in their cost estimates, but depreciation was included. It was also felt by the members that as OTEC is a

Table 3.9 : Cost of electricity for a 5 kW_p SPV system.

Rated capacity	:	5 kW_p
Annual generation (@ 1360 kWh/kW_p)	:	6800 kWh/yr
Capital cost	:	Rs. 10 lakhs
Capital recovery factor	:	0.134
Annual costs	:	1,84,000 Rs/year
Cost of electricity	:	27 Rs/kWh

Table 3.10 : Economics of OTEC plants

1.	Capacity	1.68 MW
2.	Capital costs	Rs. 30.9 crores
	2.1 plant proper	Rs. 28.78 crores
	2.2 land and site development	Rs. 0.12 crore
	2.3 preliminary expenses	Rs. 1.00 crore
	2.4 township	Rs. 1.00 crore
3.	Days operational	260
4.	Annual generation (gross)	10.48 million kWh
5.	Annual generation (net)	6.28 million kWh
6.	Capital recovery factor	0.1338
7.	Annual O & M costs (@ 3% of capital)	Rs. 0.93 crores
8.	Total annual costs	Rs 5.06 crores
9.	Cost of electricity	Rs. 8.06/kWh

Source Feasibility report prepared by MECON for an OTEC plant for Lakshadweep developing technology and, considering the vast potential for the country, priority should be given to development and that economics should not be a deciding factor at this stage.

3.3.4. Others

Devises like solar cookers, solar water heaters etc. can be used in a limited way. Installation of domestic hot water systems on roofs appears to be problematic because of the prevailing tiled-roof structures for the dwellings. There are additional problems of finding adequate space for installation and the possibility of coconuts falling onto the systems.

3.4 Battery operated Vehicles

There is no public transport system on the islands except in Kavaratti where a bus is being operated. Jeeps are used in government offices. Being high powered and hence energy intensive, it is felt that their use is not warranted for the islands where the distances to be covered are very short and the land is relatively flat. The fuel consumption figures of diesel jeeps under test conditions are shown in Tables 3.11 and 3.12. It can be seen from Table 3.11 that diesel consumption increases markedly at lower and higher speeds, the optimum being 35 kmph. Similar results are obtained with most other conventional vehicles.

Table 3.11 : Fuel consumption of diesel jeep at various speeds

Speed, kmph	Fuel Consumption, cc/km	Fuel Consumption expressed as percentage of optimum
15	129.9	186.7
20	96.6	138.8
25	80.2	115.2
30	72.2	103 7
35	69.6	100.0
40	71.1	102.2
50	82.7	118.8
60	103 0	148.0
70	130.9	187.9

Source: Road user cost study in India, Central Road Research Institute, New Delhi, 1982.

Table 3.12 : Fuel consumption of Diesel Jeep on different types of Road Surface at 35 kmph.

Roughness (mm/km)	Types of Surface	Fuel consumption (cc/km)	Fuel Consumption, expressed as percentage of minimum
3,000	Asphaltic concrete (AC)	66.66	100
5,000	Premix Carpet	69.06	103.6
6,000	Surface dressing	70.26	105.4
8,000	Freshly laid WBM	72.66	109.8
12,000	Poorly maintained WBM	77.46	116.2
15,000	Very poorly maintained WBM/ gravel/Earth surface	81.06	121.6

Increased use of conventional vehicles results in increased consumption of diesel/petrol, which may not be desirable as mentioned earlier, for ecological reasons.

Battery powered vehicles, presently manufactured by BHEL are being promoted in the mainland, chiefly as a measure of controlling air pollution. While air pollution is not a problem for the islands, factors such as energy consumption, lower speeds/power etc. have to be considered to evaluate these as alternatives to conventional vehicles. It should be mentioned here that though there is no direct diesel consumption in operating battery powered vehicles, the electricity required to charge the batteries is obtained by burning diesel in gen-sets and hence there is an indirect diesel consumption. A comparison of energy consumption for different vehicles is shown in Table 3.13. Operating data such as shown in Table 3.11 and 3.12 is not available for battery operated vehicles. The specifications indicate that the vehicle can run for 75 km per charge and that the electricity requirements are 35 kWh per charge. The Rajasthan govt. had been operating two such vehicles in Bharatpur bird sanctuary and an average of 60 km per charge had been noted by them. The basis on which comparison should be made is not clearly known because of the different capacities of the vehicles. However, diesel consumption has been calculated based on both known conventions of ton-km and

Table 3.13 : Comparison of Energy for different vehicles

Item	Diesel Jeep	Minibus	Electrovan
Weight		2.5 tons	2.85 tons
Body width		2.45 m	
Capacity (passengers)	6	28	[illegible]
Details of Electricity Consumption	--	--	75 km per charge (specs) 60 km per charge (actual) 35 kWh per charge
Diesel Consumption	0.143 lit/km	0.175 lit/km (mainland) 0.25 lit/km (islands)	0.154 lit/km (specs) @ 0.153 lit/km (actual) 0.33 lit/kWh
Total weight, including passengers		3.9 tons	3.75 tons
Diesel consumption per ton-km		0.0449 lit/ton-km (mainland) 0.064 " " (islands)	0.04 lit/ton-km (specs) 0.05 " " (actual)
Diesel consumption per passenger-km	0.024 lit/p-km	0.00625 lit/p-km (mainland) 0.009 " " (islands)	0.0085 lit/p-km (specs) 0.011 " " (actual)

passenger-km. It is obvious from Table 3.13 that diesel consumption would be about the same for both minibus and electrovan. However, diesel consumption for jeeps seems to be on the higher side and it is hence desirable to replace the jeeps by suitable battery powered vehicles, if such vehicles are available. An attempt is made to compare the economics for different options but it is again difficult to do a complete comparison as the operation and maintenance costs for battery vehicles are not known. Hence the operating costs for fuel alone are evaluated in Table 3.14. It can be seen that the running costs for the electrovan are about 3 times higher than those for conventional minibus. This is because fuel in the form of electricity is more expensive than in the form of diesel, on the islands. The total annual cost will depend upon the actual operation and maintenance costs for electrovan. O&M costs for conventional vehicles are reported to be very high as no infrastructure exists in the islands for repairs and the vehicles have to be taken to the mainland for this purpose. It is possible that the high running costs for electrovan may compensate for the low maintenance costs, but this has to be verified from practical experience. It is hence desirable to acquire a battery powered vehicle to gain operating experience under the conditions prevailing in the islands.

Table 3.14 : Cost comparisons for Minibus and Electovan for Karavatti

Item	Mininus	Electrovan
Intial cost	Rs. 1.5 lakhs (1980 prices)	Rs 2.4 lakhs (including subsidy of Rs 1.0 lakh)
Average km run per day	45	45
Average No. of passengers per run	28	18
Total No of passengers-km per year	4,59,900	2,95,650
Total consumption of diesel, lit/yr	4106	--
Total consumption of electricity, kWh/yr	--	9581
Annual running cost, Rs/yr (@ Rs. 4.00/ lit for diesel and Rs 3.5/kWh for electricity)	16424	33534
running cost, paise/p-km	3.6	11.3

3.5 Potential for Energy Conservation

Energy, either in the form of electricity or in the form of biomass, can be conserved by utilizing more efficient devices in a large scale. It has been observed, during the visit, that incandescent bulbs are predominantly used at present in the islands. These bulbs use more energy for a given luminescence output compared to fluorescent lights. The light output for incandescent bulbs is 10-12 lumens/watt, whereas that for tubelights is in the range of 50-55 lumens/watt The existing number of incandescent bulbs in office buildings in Kavaratti are tabulated in Table 3.15. The total wattage amounts to about 62.4 kW. If these are replaced by fluorescent lighting to provide the same light output, the wattage can theoretically be reduced to 15 kW, giving a saving of 47.4 kW The annual saving can be calculated as Rs. 1.5 lakh/year for Kavaratti alone. The Tata Energy Research Institute had conducted a study on energy efficient lighting under a project sponsored by the Advisory Board on Energy. Either TERI or ABE might be consulted for a fuller investigation of the scope for energy efficient lighting in the islands.

It has also been noted that thermal energy applications like cooking and 'mas' making are consuming huge quantities of biomass because of using very inefficient devices. The efficiency of 'mas' making is estimated to be roughly 2.6%. High efficient metal stoves, such as those used at present in mid-day meals

Table 3.15 : Potential for electricity conservation by using fluorescent lights in offices (Kavaratti)

Office	Number of bulbs				Total Wattage
	25 W	40 W	60 W	100 W	
	(1)	(2)	(3)	(4)	(5)
Fisheries	1	6	10	51	5965
Harbour North	-	-	2	-	120
Port Workshop office	-	2	5	4	780
Passenger Hall	-	4	3	-	340
New India Assurance	-	-	2	-	120
Main Hatchery	-	-	8	-	480
Cooperative Society	-	-	3	1	280
Furniture Society	-	-	2	-	120
Service Society	-	12	-	-	480
W/L North	-	-	-	5	500
Post Office	-	-	3	-	180
DCIO Office	-	3	7	-	540
Satellite	-	-	22	-	1320
Medical Directorate	-	21	3	-	1020
Education Directorate	-	19	-	-	760
S.W.O. Office	-	1	11	-	700
Employment Office	-	6	3	-	420
Botanical garden	-	7	-	7	980
W/L south	-	4	3	2	540
Doordarshan	-	-	4	1	340
Hospital ward	-	27	33	-	3060
Paediatric ward	-	20	6	-	1160
Hospital	-	21	-	-	840
Secretariat	1	80	31	5	5585
Navy	2	74	-	-	3010
Helipad	-	10	-	-	400
S B School	1	3	-	-	125
High School Office	14	-	20	-	1550
College Office	9	19	-	-	985
Handicraft	1	1	-	-	65
DRDA Office	5	24	6	-	1445
Telephone	4	5	-	-	300
AE W/L	3	6	6	-	675
AGM Office	2	5	6	-	610
PWD Subdivision	4	1	6	6	1100
Govt. Press Office	20	-	30	-	2300
PWD J.E	1	1	2	6	785
A.E. Housing	4	-	12	-	820
Industries News	2	-	22	16	2970
Hindi Pracharak	2	-	5	-	350
Tashsildar Office	2	-	8	-	530

Table 3.15 (Contd.)

Office	Number of bulbs 25 W (1)	 40 W (2)	 60 W (3)	 100 W (4)	Total Wattage (5)
Treasury	3	-	3	7	955
ISPW	4	-	8	4	980
EHW Division	16	-	96	-	6160
Elec. Division	10	-	20	-	1450
Vet. Office	5	21	-	-	965
Vet. Directorate	6	16	-	-	790
MPSAF Office	1	2	-	-	105
W/L Beacon	8	16	-	-	840
Education	1	4	-	-	185
Sahithyakala	12	22	-	-	1180
Information Office	9	20	4	1	1365
Co-op. Register	11	20	5	-	1375
LSSWA	4	13	-	-	620
Total					62360

Lumens emitted (@ 12 lumes/watt) = 748320
Wattage with fluoroscent lighting (@ 50 lumens/watt) = 14966
Saving in power = 47.394 kW
Annual saving in electricity = 113760 kWj/yr
Annual diesel saving = 37540 lit/yr
Annual monetary saving ≃ Rs. 1.5 lakh/yr

scheme in Tamil Nadu and other places, might be extremely appropriate for 'mas' making. Similarly, metal stoves with proven field performance in fuel saving, might be promoted in large scale in the islands for cooking purposes. The biomass thus saved can be made available for use such as gasification in the long run, besides solving the present fuel shortage problem in islands where 'mas' making is extensive.

3.6 Potential for Tidal and Wave Power

Tidal energy and wave energy of the ocean might well provide for all the the electricity needs of the islands. Unfortunately, there is not sufficient expertise in the country in this field at present. Besides, devices for conversion of this important sources of energy into more useful forms such as electricity, are commercially not available, though many prototypes and projects had been conceived in the past. For a complete investigation of the potential as well as means of utilization of wave power known experts in the field may be contacted

4. MAJOR RECOMMENDATIONS

1. There seems to be a significant potential for utilization of biomass (coconut waste) in some islands. The technology of pulverisation, pelletisation, and gasification can be used to generate electricity. As the complete process has not yet been proved technically viable, a feasibility study - pilot scale demonstration path may be planned in the near future. Preliminary calculations indicate that the project could be economically viable.
2. Wind energy utilization is potentially viable for the islands Kavaratti, Amini and Agatti, especially during monsoon. However, the performance of the present 20 kW WEG in Kavaratti should be observed for monsoon months to assess the economic viability of the system It is also highly desirable to install wind speed monitors at suitable heights in all the islands to assess the full potential of wind energy utilization.
3. Solar energy utilization has a limited potential. Solar desalination systems are quite appropriate for the islands Bitra and Suheli Some measures might be taken to improve the performance of the present desalination plant in Bitra. Solar PV systems, though technically viable, are expensive options at the present

juncture. Solar DHW systems and solar cookers can be encouraged in a limited way. OTEC system is economically not viable at the present level of development of the technology.

4. Battery operated vehicles would consume the same amount of diesel indirectly, as conventional buses. However, smaller battery vehicles which can replace the existing diesel jeeps can be tried if available. Also, it is desirable to acquire first hand experience in operating battery powered vehicles to assess the problems of maintenance in the islands.
5. Energy conservation, both electrical and thermal, may be accorded top priority. Energy efficient lighting using fluorescent lights and fuel saving metal stoves both for 'mas; preparation and for cooking can be popularised in the near future.
6. As a long-term option, tidal and wave power utilization should be examined. The technology for utilization of the ocean power is not available commercially at present.

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APPENDIX - I

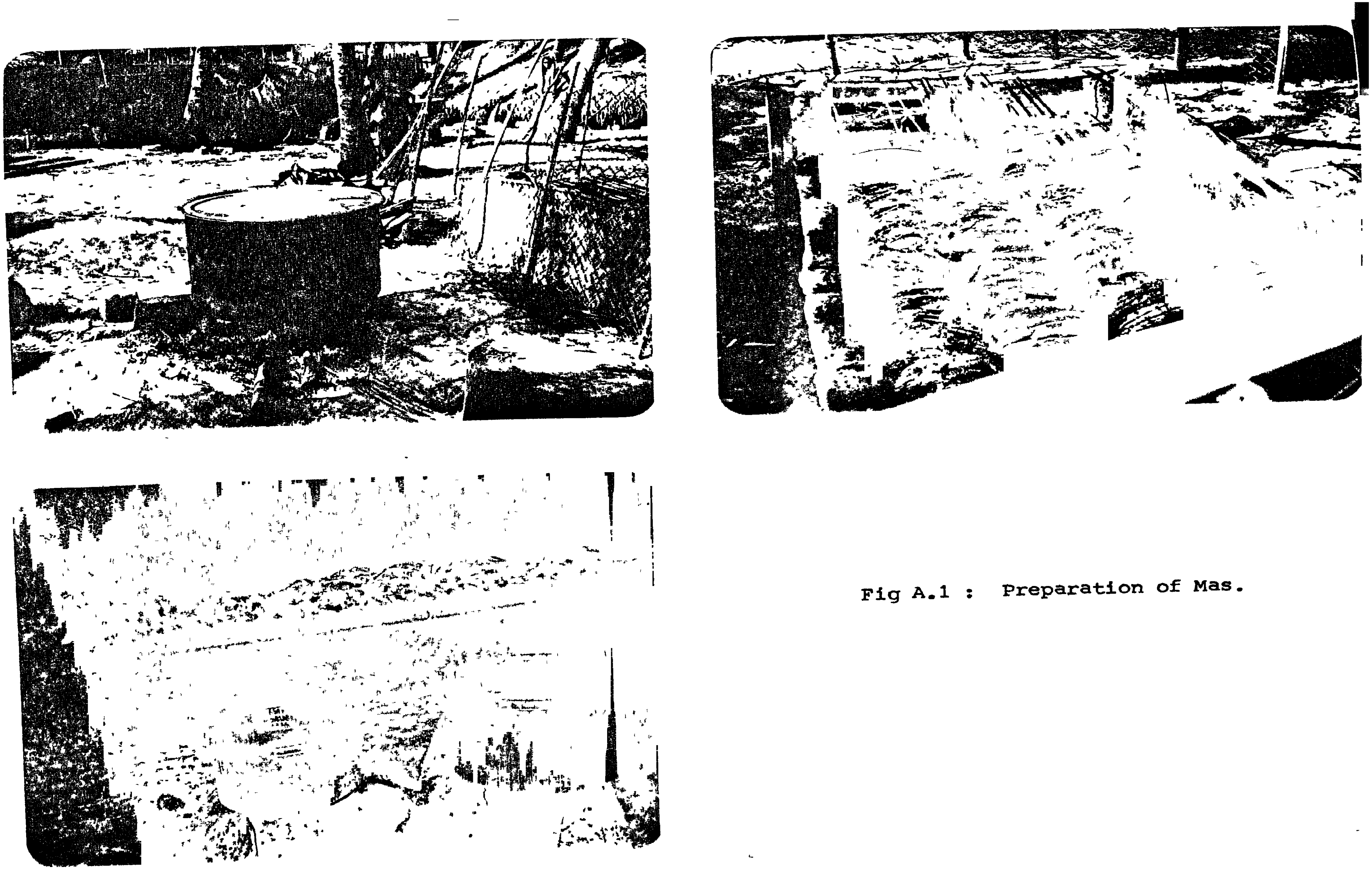

Fig A.1 : Preparation of Mas.

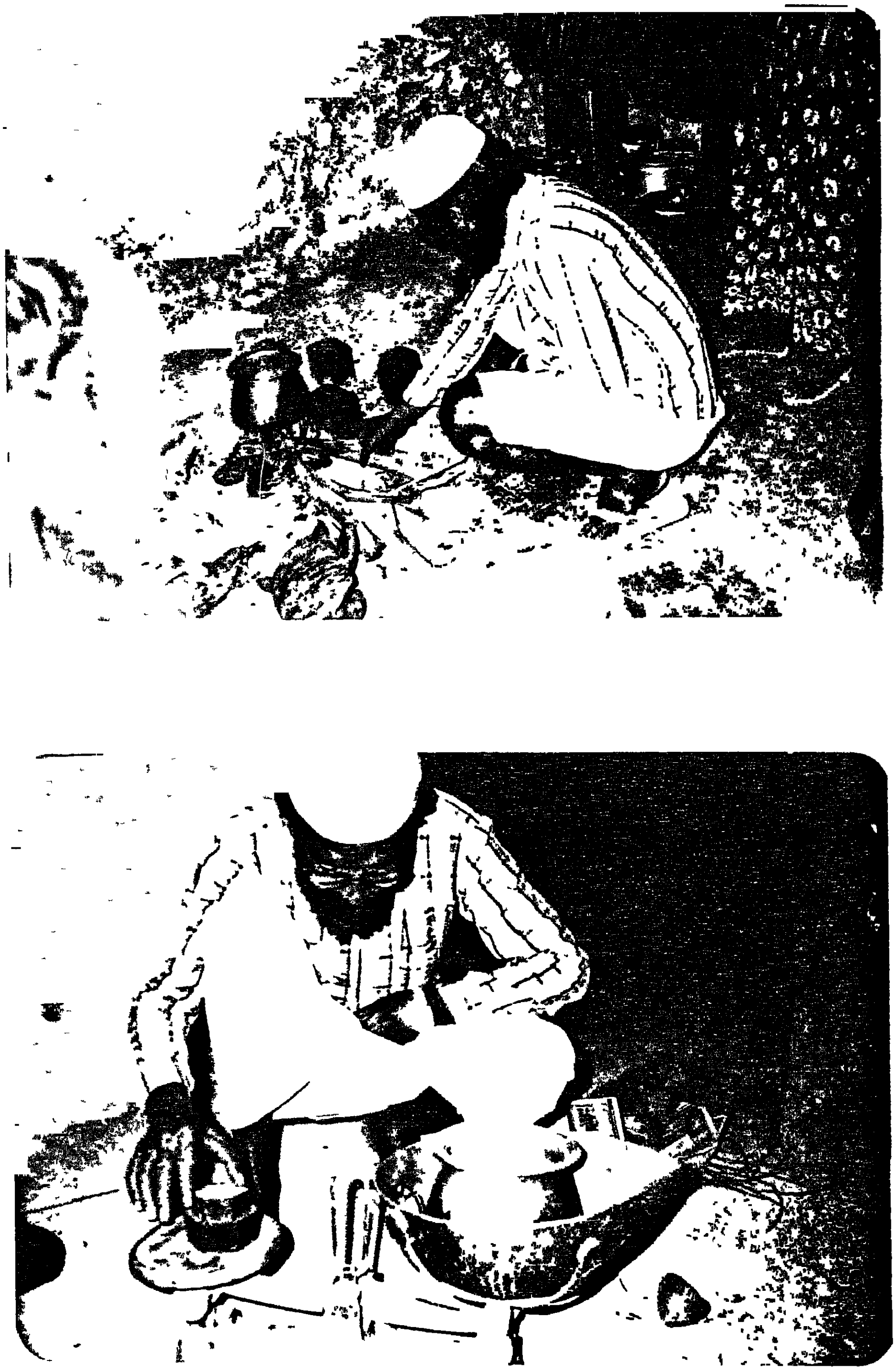

Fig A.2 : Experiment to determine Fuel Consumption for Cooking.

Fig A.3 : The 20 kW Wind Electric Converter at Kavaratti.

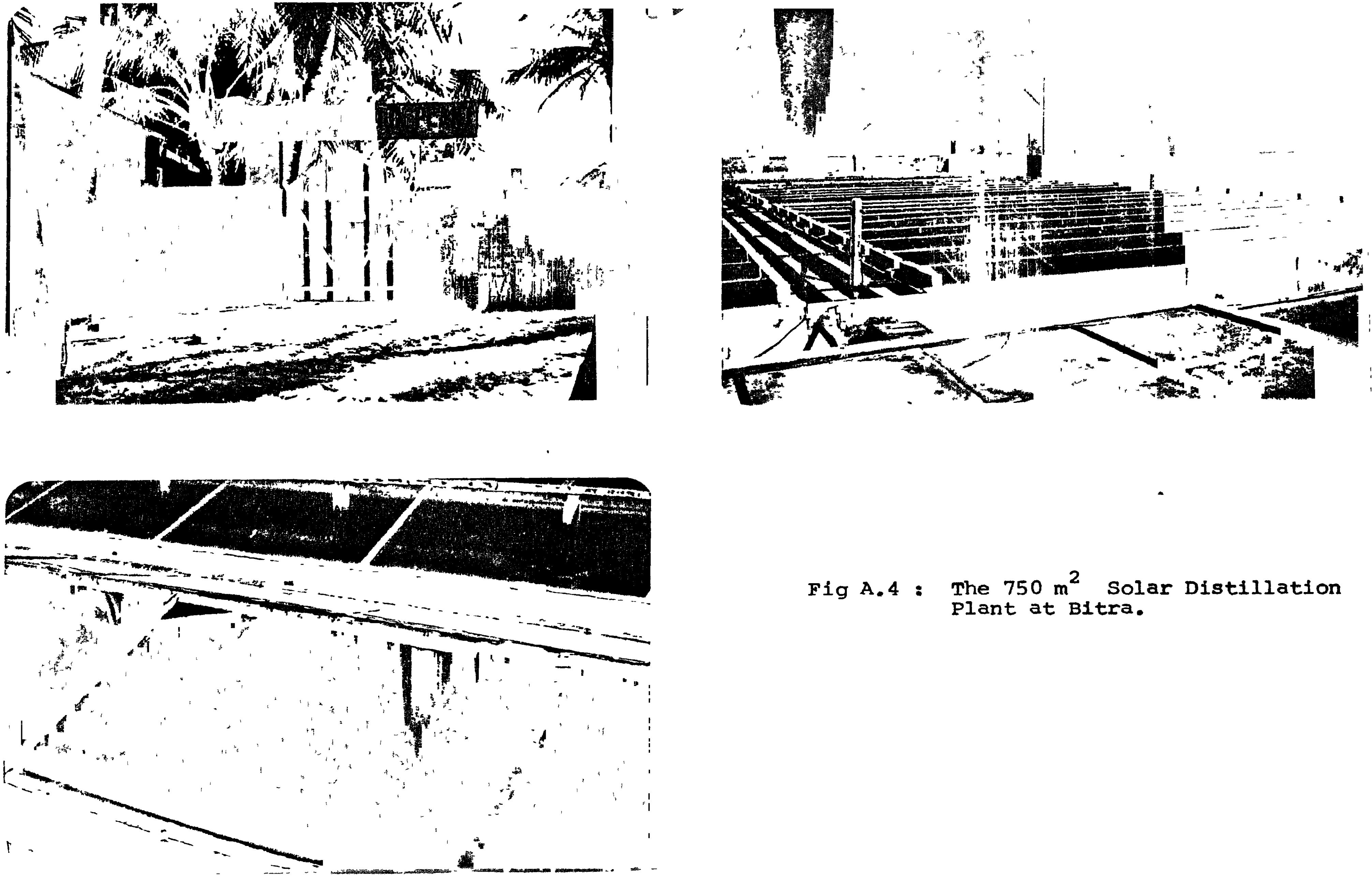

Fig A.4 : The 750 m^2 Solar Distillation Plant at Bitra.

Fig A.5 : Solar Photovoltaic System for a 10 W TV Transmitter.

APPENDIX - II

UTILIZATION OF NON-CONVENTIONAL ENERGY DEVICES AND SYSTEMS IN LAKSHADWEEP GROUP OF ISLANDS

ACTION PLAN

As a follow-up of exploratory visits undertaken previously by different experts sent by DNES to assess the availability of resources and energy requirements of the Islands, Secretary, DNES led a team of officials from DNES and BHEL to the Islands between May 8 and 11, 1988 for an on-the-spot inspection, and to identify projects and programmes for meeting the energy requirements of the Islands, mainly from non-conventional energy sources. During its stay, the team visited Kavaratti, Agatti, Bitra and Bangaram Islands. Several rounds of discussions were held with the Administrator and local officials. Visits were undertaken to various project sites, and several potential locations were identified for further projects.

The team comprised the following officials:

1. Dr. Maheshwar Dayal, Secretary
2. Shri G.P. Dodeja, Executive Director, BHEL
3. Shri K.K. Singh, PSO
4. Shri Ajit K. Gupta, PSO
5. Dr. Praveen Saxena, SSO - I

An outcome of the visit is a Plan of Action for a package of initiatives to be undertaken in the remaining two years of the Seventh Plan, along with a Perspective Plan.

ACTION PLAN PROPOSED FOR 1988 - 90

I. COOKING ENERGY

1. Improved Chulhas

i) 200 numbers of the portable type 'Priyagni' model have been ordered by the Administration from M/s Heat Systems, Bangalore. DNES will expedite their delivery.

ii) The local Social Welfare Board will arrange to send two ladies for training at a technical back-up unit, at Bangalore or Delhi.

iii) An officer of the Administration will visit the technical back-up unit at IIT, Delhi, to see various models of chulhas available with a view to select a few models suitable for the Islands and best possible adaptation

Targets for 1988-90 : 300 improved chulhas

2. Solar Cookers

DNES will arrange a demonstration of solar cookers at Kavaratti. 5-10 solar cookers will be taken for trials and demonstration.

3. Community Stoves for 'mas' making

Community fuel-efficient stoves can be provided for 'mas' making, particularly in the Agatti, Minicoy and Bitra islands. The improved stoves will be particularly of use in the first step of cooking where tuna fish is boiled in sea water for about an hour. The stove could be of 'Paru' type or the large commercial stove available at the Delhi unit.

Targets for 1988-90 : 100 community stoves

4. Fuel briquettes based on coconut waste

DNES will take up the development of suitable systems for conversion of coconut waste into fuel briquettes for use in improved stoves. The units will be first tried in the islands where the coconut waste is in excess and will be closely linked to the Improved Chulha programme.

Targets for 1988-90 : 2 demonstration units

II. POWER GENERATION

1. Biomass Gasification

Coconut pith is presently being wasted from the four coir factories in the islands. This pith which is causing environmental degradation, can be utilized for production of power through biomass gasifiers/sterling engines. DNES will commission feasibility studies for the establishment of pilot power generation units based on this input material. The power generated will be used to meet the power requirements of the factories and make them self-sustaining.

Targets for 1988-90 : 2 demonstration units of unit size 20 - 30 KW

2. Wind Electric Generators

The 20 KW wind electric generator installed at Kavaratti has performed well, and according to the available wind data, possibilities of wind power generation in some of the islands appear to be quite attractive. The local administration is installing cup-counter anemometers (obtained from IMD, Pune) and one MAN classifier in 8 of the islands. In addition, DNES will also commission feasibility reports for the installation of 100 KW wind electric systems, either working with induction or synchronous generators.

Targets for 1988-90	**: 4 Nos. 100 KW WEGs. Two at Kavaratti and one at Amini, with another in a suitable location**

3. Solar Photovoltaic Power Plants

The 5 KW solar PV power plant installed by DNES at Bitra island was dedicated by Secretary, DNES on 10th May. The power plant is functioning satisfactorily and is able to successfully meet part of power requirements of the island and to offset the use of diesel. Addition of 10 KW capacity is proposed to meet full needs of power by photovoltaics on Bitra Island. Further 5 - 10 KW solar power packages will be installed at appropriate locations on other islands.

Targets for 1988-90	**: 1 No. 10 KW SPV power plant at Bitra** **2 Nos. 5 KW solar Pv power plants**

4. Solar PV lighting, communications and TV's

It was felt that solar PV streetlights can be increasingly used particularly for office and residential complexes and for other appropriate uses on the islands. Solar PV based communication system, TVs and individual lights are also proposed to be installed with an aggregate capacity of about 5 KW.

III. INTEGRATED NON-CONVENTIONAL ENERGY POWER SYSTEMS FOR BANGARAM ISLAND

The total requirement of power at the tourist island of Bangaram is today under 20 KW. DNES will install appropriate solar and wind power systems to meet the entire power needs of the Island

Target : **To meet entire power needs of Bangaram by 1990**

(About 25 KW power system including a wind generator and a PV solar power plant)

IV TRANSPORTATION SYSTEMS

1. BHEL electrovan has already reached Cochin on way to Lakshadweep. However, as certain changes were requested by the Administrator, particularly, in the seating plan, BHEL will now replace this van by a 14 seater delux model. This will be arranged by BHEl immediately.

2. The Administration is also planning to procure a 5 seater 'saloon'type electric van from M/s Chatelec.

3. BHEL will undertake the conversion of a Maruti 'gypsy' to be run on batteries. This will be completed in 3 months. After trials, this could be a suitable replacement for the diesel/petrol jeeps (total 20 numbers) being used in all the islands for official work.

4. There are about 25 three-wheelers being run on commercial basis on Kavaratti island. BHEL agreed to convert a three-wheeler to be run on batteries for the islands taking into account the daily requirements of the islands.

5. Work will be started on development of battery-driven two wheelers, 'sand buggies' for tourists, hybrid diesel plus battery operated boats for inter-island communications, as well as battery-driven boats for tourists to observe corals and aquatic life on the lagoon bed. An objective is to reduce and eventually eliminate diesel use in the lagoons to avoid chances of pollution in the lagoons.

Targets 1988-90 : i)	**Electric vehicles**	**5 + 20**
ii)	**Mixed electric vehicles (Three wheelers, two wheelers etc.)**	**10**
iii)	**Electric + diesel boats**	**10**

V ENERGY CONSERVATION

DNES recommended that the Administration should attach priority to the replacement of incandescent bulbs in the island by more efficient low wattage lamps for example PL 5, PL 7, PL 9 Series. Administration will replace all the lights in the official buildings and complexes and streetlights by such lamps. They will also consider various promotional schemes for making such replacements attractive for private users. Some of the measures discussed related to exemption from duties and taxes, differential electricity tariff, costing of low wattage lamps at the same cost as incandescent bulbs, etc.

Targets 1988-90 : 1000 lamps

VI POTABLE DRINKING WATER

It is proposed to have a separate detailed examination of the issue of fresh water for the growing needs of the Islands, utilizing solar and wind energy technologies. One solar distillation unit for providing drinking water is already in operation on Bitra Island. A few experimental units based on Reverse Osmosis and Electro-dialysis are also planned through HSL and CSMCRI. Other possibilities such as 'flash' distillation could also be explored.

The above Action Plan for 1988-90 will involve a total financial requirement of approximately Rs.3.5 crores over the two year period.

VII PERSPECTIVE PLAN

It is encouraging to note that a number of non-conventional energy systems are already providing regular service in Lakshadweep. It was felt that in view of, on the one hand, availability of renewable sources of energy, such as solar, wind and biomass on the Islands, while on the other hand, the difficulties, high cost, and pollution hazards, involved in transportation and storage of conventional fuels such as diesel and kerosene, it should be possible to completely phase out the use of diesel and kerosene on the Islands within a ten-year time frame. Some of the technologies are sufficiently developed at present, like wind power, solar power, biomass based conversion systems, etc. and these should be increasingly deployed. Other new technologies such as power from waves and ocean thermal energy conversion (OTEC) would get developed over this period. It is expected that the cost of some of the existing technologies will decrease further, along with improvement in efficiency and reliability of various systems and devices. It is suggested that the work of detailed project reports may be taken up towards preparation of such a perspective plan. In the meanwhile, over the next two years, further experience will be gained in the development, installation and performance of various NRSE systems that will be introduced immediately.

UTILIZATION OF NRSE IN LAKSHADWEEP GROUP OF ISLANDS

TARGETS FOR 1988 - 90

1. Improved Chulhas : 300 numbers
2. Solar Cookers : 100 numbers
3. Community Stoves : 100 numbers
4. Fuel Briquetting units : 2 numbers
5. Biomass gasifiers/ Sterling Engineers : 2 units (20-30 KW)
6. Wind Electric Generators : 4 numbers (100 KW x 4)
7. Solar PV Power Plants : 3 numbers (10 KW x 1 + 5 KW x 2)
8. Solar PV Streetlights : 50 numbers
9. Solar PV units for communications, TV and individual lighting : Aggregate capacity about : 5 KW
10. Integrated NRSE systems for Bangaram Island : 25 KW power from wind & SPV by 1990
11. Electric - boats : 10
12. Misc. vehicles : 10
13. Low wattage lamps : 1000

TOTAL FINANCIAL REQUIREMENTS WILL BE ABOUT RS.3.50 CRORES